

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**

(43) Date of A Publication 21.02.2001

(21) Application No 0018136.2

(22) Date of Filing 24.07.2000

(30) Priority Data

(31) 9917267

(32) 22.07.1999

(33) GB

(71) Applicant(s)

Smith International Inc
(Incorporated in USA - Delaware)
16740 Hardy Street, Houston, Texas 77205-0068,
United States of America

(72) Inventor(s)

Brian Cruickshank
John Patrick Boyce
Christopher John Caton
Bruce McGarian

(51) INT CL⁷

E21B 4/02

(52) UK CL (Edition S)

F1F FEY F1N1

U1S S1761

(56) Documents Cited

US 4705117 A

(58) Field of Search

UK CL (Edition R) E1F FEF , F1F FEY

INT CL⁷ E21B 4/02

Online:WPI,EPODOC,JAPIO

(74) Agent and/or Address for Service

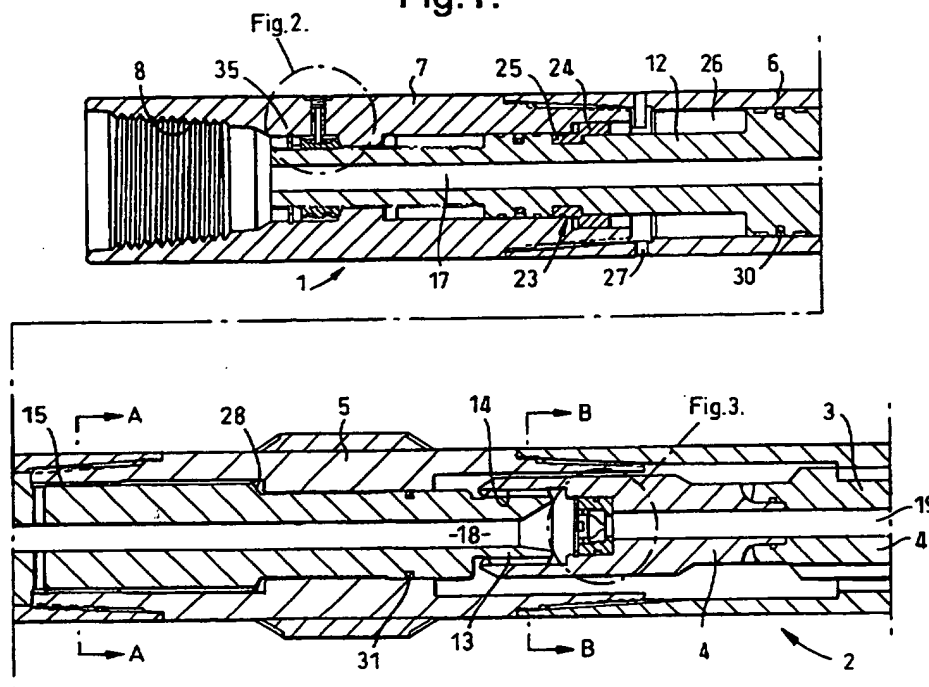
A.A.Thornton & Co
235 High Holborn, LONDON, WC1V 7LE,
United Kingdom

(54) Abstract Title

Lockable motor assembly for use in a well bore

(57) A lockable motor assembly (1) for use in a well bore comprises a PDM motor (2) having a rotor (4) and a stator (3). A locking member (12) has a splined projection (13) which is received within a splined recess (14) of the rotor and external splines (15) which mate with splines provided on a sub (5) connected to the stator. The components are held in this configuration by a shear ring (23) until the fluid pressure within a chamber (28) defined between the locking member (12) and the sub (5) is sufficient to cause the shear ring to shear. The locking member (12) may then move out of the engagement with the rotor to free the motor for operation. The locking member is held in this position by a ratchet mechanism (35).

Fig.1.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

Fig.1.

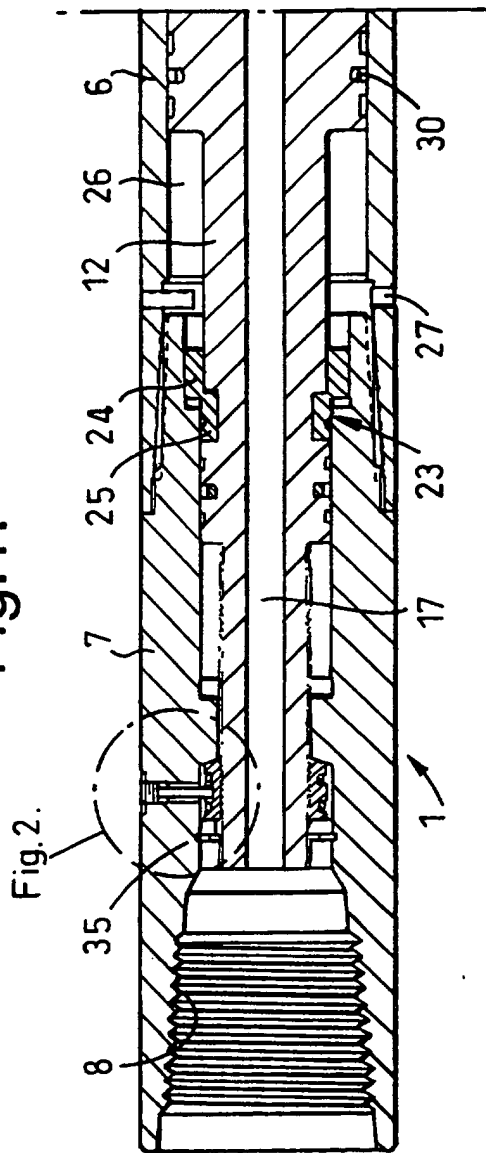


Fig.2.

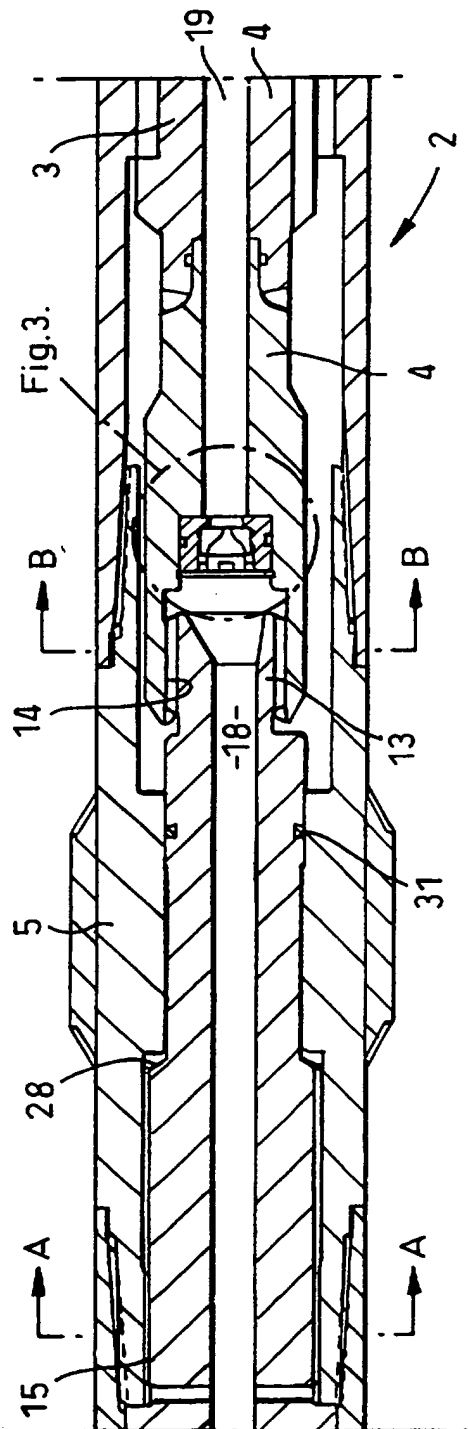


Fig.3.

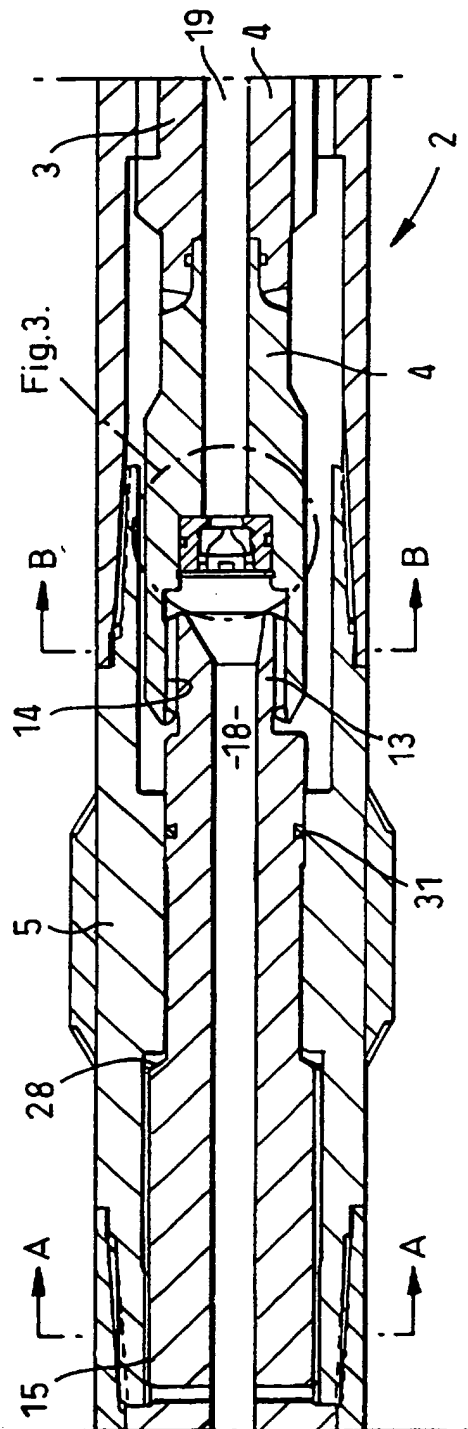


Fig.2.

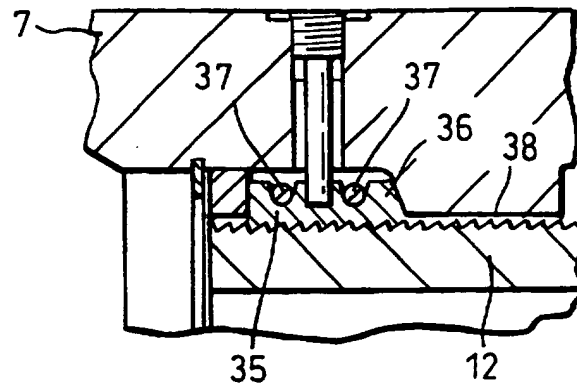


Fig.3.

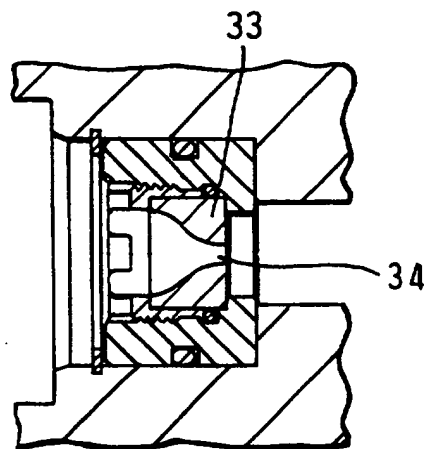


Fig.4.

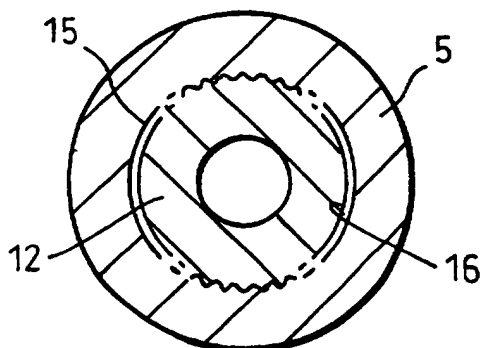


Fig.5.

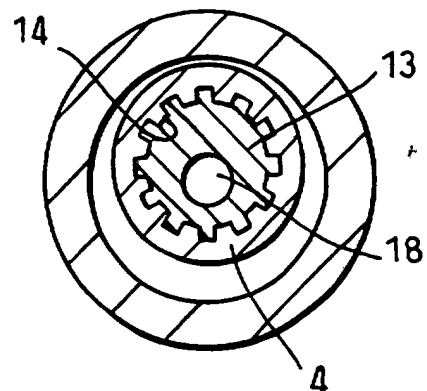


Fig. 6.

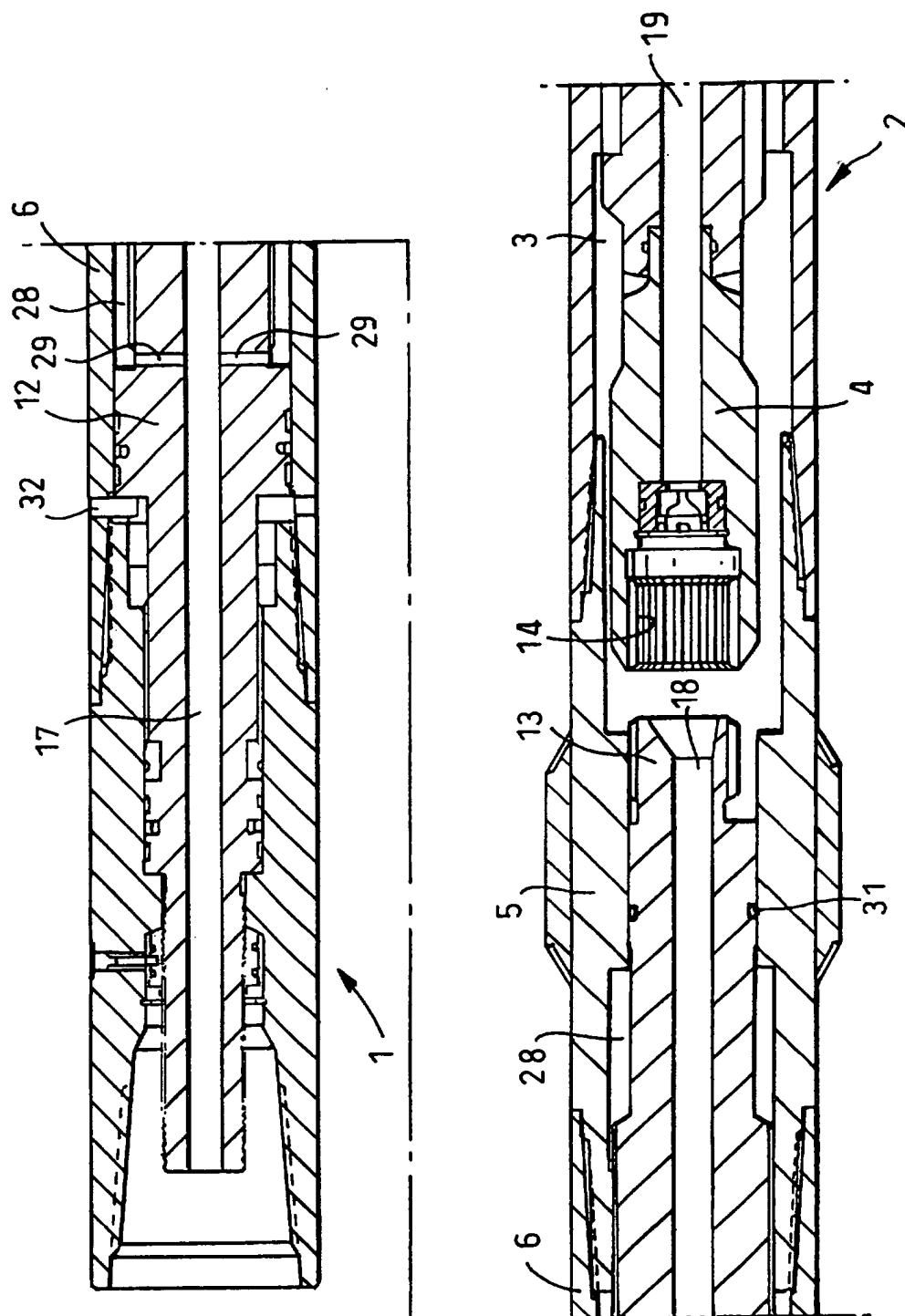
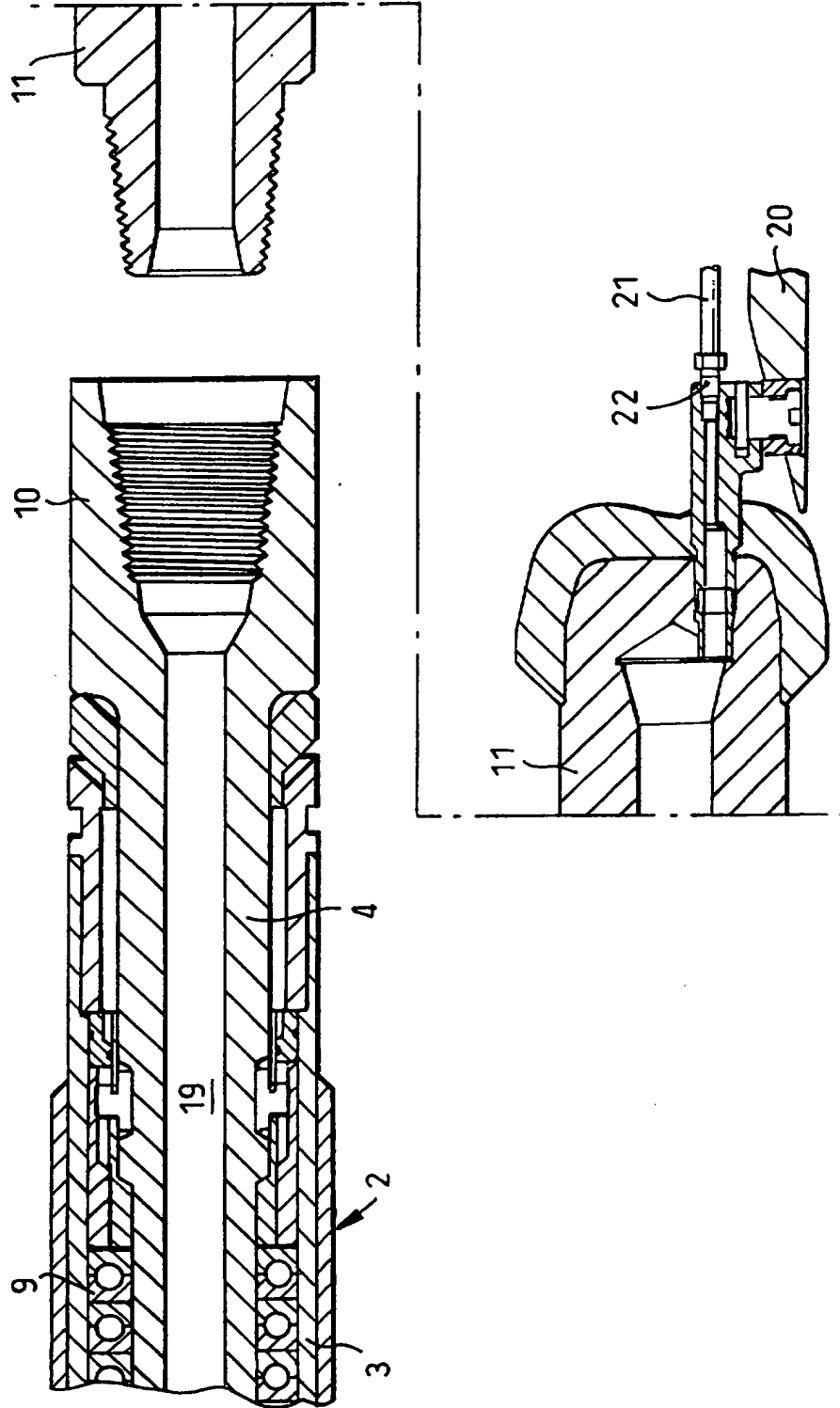


Fig.7.



LOCKABLE MOTOR ASSEMBLY FOR USE IN A WELL BORE

This invention relates to a lockable motor assembly for use in a well bore.

The use of a downhole motor to drive a rotating tool, for example a milling tool, in a downhole assembly has well recognised advantages. Downhole motors available heretofore have, however, suffered from the disadvantage that the rotor of the motor cannot be locked to the stator of the motor. As a result, relative rotation of the elements of a tool assembly above and below the motor is possible. This renders impossible or at least complicates the accurate angular orientation of the components located below the motor.

If the components below the motor include a hydraulically settable packer or anchor, the fluid displacement required to set the packer or anchor is liable to drive the motor during the setting procedure, further complicating accurate angular orientation of the tool.

In certain applications, for example the drilling of a lateral well bore from a main well bore using a whipstock to deflect a milling tool, accurate angular orientation of certain components (the whipstock in this case) is critical.

The inability of known downhole motors to be locked during setting of the whipstock and subsequently selectively released to enable a milling tool to be driven has seriously limited the use of downhole motors in such applications.

In accordance with the present invention a lockable motor assembly for use in a well bore comprises: the stator; a rotor rotatably mounted in the stator; a locking member movable axially of the motor between a first position in which the locking member is rotationally fast with the stator and is in engagement with the rotor to prevent rotation of the rotor relative to the stator, and a second position in which one of the stator and the rotor is free to rotate relative to the locking member to permit relative rotation between the stator and the rotor; and holding means for holding the locking member in the first position and selectively releasable to permit the locking member to move to the second position.

Preferably, the locking member when in its first position is rotationally fast with the rotor and when in its second position is spaced from the rotor to permit rotation of the rotor relative to the locking member and the stator. If the motor is of the type in which the rotor, in use, rotates about a fixed axis (if for example it is of the vane type, the turbine type or the positive displacement type), the locking member preferably has a non-circular profile which, when the locking member is in the first position, engages a complementary non-circular profile provided on the rotor. The non-circular profile on the locking member preferably takes the form of a projection which, when the locking member is in the first position, engages a complementary recess provided in the rotor. The non-circular profile is preferably provided by a plurality of splines.

If the motor is of the PDM type, the rotator will, in use, rotate about an axis which itself precesses around a circular path. Under these circumstances it is not strictly necessary for the locking member and the rotor to have complimentary inter-engaging non-circular profiles. As long as the locking member prevents precessional movement of the rotor axis the rotator will be locked against rotation. The locking member and the rotor may accordingly have mating circular profiles, or engage each other in some other way. However, even if the motor is of the PDM type the rotor may be locked by use of mating non-circular profiles on the locking member and the rotor.

Preferably, means sensitive to hydraulic pressure within the motor assembly are provided for releasing the holding means when the pressure within the motor assembly reaches a predetermined value. Preferably, the pressure sensitive means comprises a differential area piston provided by the locking member.

Preferable the holding means comprises one or more shear elements, for example one or more shear pins or a shear ring.

Preferably, means are provided for maintaining the locking member in the second position after it has been shifted from the first position to the second position.

Preferably, the locking member includes a through passage which provides fluid communication from the proximal end of the motor assembly to the input to the motor.

Preferably, if the motor is of the PDM type the rotor thereof will include a through passage which, when the locking member is in its first position, communicates with the through passage in the locking member to provide a fluid passage from the proximal end of the motor assembly to the distal end thereof. This fluid passage may conveniently be used to communicate fluid pressure to a packer, an anchor or other tool which is connected to the motor assembly and located below the motor assembly. If the motor is of a type (for example a vane type) which permits some flow through the motor even when the rotor is locked, the provision of a through passage in the rotor may not be necessary to set a packer or anchor, but none the less may be desirable since it will allow fluid to be pumped through the motor to perform auxiliary function below the motor, e.g. bit cooling or cuttings removal.

If a packer or anchor is connected to the motor, the shear means may be designed to shear at a pressure higher than the setting pressure of the packer or anchor so that a complete assembly which includes the motor assembly and the packer/anchor may be run into a well bore, rotationally oriented, the packer/anchor set, and the shear means sheared to release the motor for rotation, all in a single trip. Preferably, a whipstock and a mill will be located between the motor and the packer/anchor so that after the packer/anchor has been set and the locking member has been moved to the second position to release the rotor, the motor can be operated to rotate the mill and form a window in the well casing.

Preferably, the motor is a PDM motor with directional drilling ability.

The preferred embodiment of the invention permits an assembly of one or more packers and/or anchors, a whipstock, one or more mills and/or bits, and a locked PDM motor to be run in to a well bore in a single trip. The assembly can be rotated to orient the whipstock correctly using appropriate orientation techniques. The pressure in the tubing string may then be increased to sequentially set the packer/anchor(s) and move the locking member to its second position thereby releasing the PDM motor rotor for rotation. The mill can then be sheared from the whipstock and mud flow increased to activate the motor and commence milling. Accordingly, a PDM powered whipstock milling assembly may be run in to a well, oriented, set, and activated to mill a window in a casing in a single trip. If the lead mill is of an appropriate type, for

example a PDC bit designed to drill formation, the assembly may be used to drill to the required depth after it has broken through the casing. Accordingly all the steps necessary to drill a lateral may be completed in a single trip.

The above and further features and advantages of the invention will be come clear from the following description of a preferred embodiment thereof, given by way of example only, reference being had to the accompanying drawings wherein:

Figure 1 illustrates schematically in longitudinal cross-section the upper portion of a lockable motor assembly in accordance with a preferred embodiment of the invention, the locking member being in its first position locking the rotor of the motor against rotation;

Figures 2 and 3 and detailed views of portions of Figure 1;

Figures 4 and 5 are cross-sections respectively on the lines A-A and B-B of Figure 1;

Figure 6 is a view corresponding to Figure 1 but showing the locking member in its second position;

Figure 7 is an exploded schematic view of the lower portion of the motor illustrating Figures 1 and 6 and shows schematically a milling tool and the upper end of a whipstock for connection to the motor assembly.

Referring firstly to Figures 1-5 the illustrated lockable motor assembly 1 comprises a motor 2 having a stator 3 and a rotor 4. The stator 3 is connected by an assembly of subs 5, 6, 7 to a conventional API box connector 8 by which the motor assembly may be connected to a drill string or coil tubing. The rotor 4 is mounted within the stator 3 by suitable bearings, including bearings 9 and has, as its lower end, a further box connection 10.

The motor may have sealed bearings or normally open bearings. If it is of the normally open bearing type it may be desirable to provide temporary sealing of the bearings during the packer/anchor setting procedure. The temporary bearing seals may, for example, be O-ring seals which are rapidly destroyed upon rotation of the rotor relative to the stator.

In the illustrated assembly a milling bit 11 is a PDC bit capable of drilling formation as well as milling through well casing. The bit 11 is connected to the rotor box 10 by one or more tubing lengths (not shown).

The motor is a PDM motor and is powered by means of drilling mud supplied to the assembly by the drill string or coil tubing.

As run into the well the rotor 4 of the motor is locked to the stator 3 by the means of a locking member 12. The locking members include an externally splined projection 13 which mates with an internally splined recess 14 provided in the end of the rotor. The locking member is provided with further external splines 15 which engage with mating splines 16 in a stabiliser sub 5 which is itself connected to the motor stator 3. Accordingly, when the locking member is in its first position, as illustrated in Figure 1, the motor rotor 4 cannot rotate relative to the motor stator 3.

The use of a stabiliser sub 5 is particularly desirable where the complete assembly will be used for directional drilling. However, there may be applications of the invention where a stabiliser sub is not required and accordingly a slick may under these circumstances be used rather than a stabiliser sub.

The locking member includes a longitudinal through passage 17 which extends along the entire length thereof and, at its lower (distal) end 18, communicates with a longitudinal through passage 19 extending through the rotor. Accordingly, a fluid passage is established through the tool from the top box 8 to the bottom box 10. This fluid passage may be used to communicate fluid pressure to a device located below the motor, for example a packer or anchor located at the bottom of a whipstock 20. For this purpose, a passage is provided through the tubing lengths which connect the rotor 4 to the milling tool 11 and a flexible connecting hose 21 is connected to an appropriate nipple 22 provided on the milling tool. Thus, when the assembly is being run in to a well fluid pressure may be applied to set a packer located below the whipstock via the hose 21.

It will be noted that the joint between the projection 13 and the recess 14 is not hydraulically sealed. Accordingly, fluid pressure within the passages 17 and 19 will be communicated to the power fluid inlet of the motor, thereby ensuring hydraulic pressure balance above and below the stator.

As run in to the well, the locking member 12 is maintained in its first position by a shear ring 23 which includes a first part 24 and a second part 25 connected by a relatively thin web. The ring is located such that an upward force on the locking member will bring the first part 24 of the shear ring into engagement with the shoulder provided on the sub 7 and will bring the second part 25 of the shear ring into engagement with the shoulder provided on the locking member 12. The web between the first and second parts of the shear ring is frangible and will shear when a predetermined force is applied to the locking member relative to the sub.

The function of the shear ring 23 is to hold the locking member in its first position until it is desired to release the motor for rotation. This holding function may be performed by means other than the shear ring 23. It may, for example, be performed by one or more shear pins or by some other holding element capable of holding the locking member in its first position until the locking member is selectively released and moved to its second position.

In order to generate a force on the locking member 12 to shear the shear ring 23 an annular chamber 26 is designed between the sub 6 and the locking member 12. The annular chamber 26 is connected to the exterior of the tool by a passage 27 so that annulus pressure subsists in the annular chamber 26. A further annular chamber 28 is provided between the locking member 12 and the sub 5 and is connected to the longitudinal through passage 17 of the locking member by radial passage 29. The annular chamber 28 is defined between seals 30, 31 located on the locking member. Accordingly, if pressure within the through passage 17 of the locking member exceeds the pressure within the annulus surrounding the tool, a force will be generated on the locking member 12 tending to move it away from the motor 2. This force will be resisted by the shear ring 23 until the shear force of the shear ring is exceeded whereupon the locking member will move rapidly away from the motor until its movement is arrested by a pin 32 provided on the sub 6. This configuration of the components is illustrated in Figure 6. It will be noted that the splined projection 13 of the locking member has moved clear of the splined recess 14 of the rotor, thereby freeing the rotor for rotation. Also, the through passage 17 of the locking member is now positioned to supply drilling fluid to the motor for operation thereof.

The fluid pressure necessary to shear the shear ring 23 may be generated by a hydrostatic pressure, for example by designing the shear ring so that the shear force required to shear it is substantially higher than the hydrostatic pressure required to set the packer. Under these circumstances, the tool may be run into the well, oriented as necessary, and fluid pressure applied to the tool to set the packer. Once the packer has been set and the set confirmed by applying a vertical load to the packer, fluid pressure is increased until a sufficient hydraulic force is generated on the locking member to shear the shear ring.

In order to control the amount of fluid flowing through passage 19 during operation of the motor, a nozzle 33 is preferably provided. The nozzle may be chosen to have an aperture 34 allowing fluid to flow through the nozzle to set the packer, but restricting the rate of flow of fluid once the rotor has been released and the motor is in operation.

Preferably, a ratchet ring 35 is provided for holding the locking member 12 in its second position, after it has moved into its second position upon shearing of the shear ring 23. The ratchet ring may be a single ring or may comprises a plurality of ratchet segments 36 held by means of spring clips 37 around a ratchet tooth area 38 provided on the locking member. Once the locking member has moved into the position illustrated in Figure 6 it is unable to move downwardly so long as the ratchet ring 35 is in operation. Accordingly, there is no danger that vibration or fluid pressure or flow effects will cause the locking member to return to a position where it can engage the motor rotor.

It will be noted that once the motor assembly has been recovered it can readily be reset to the locked condition illustrated in Fig. 1. To achieve this, the sub 7 is separated from the sub 6 to permit the replacement of the shear ring 23 with a fresh shear ring. To facilitate assembly the shear ring is preferably split into two or more parts. The rotor is then manually rotated to align the projection 13 with the recess 14 and the locking member 12 is again engaged with the rotor. The sub 7 is then replaced and the motor assembly is ready for re-use.

CLAIMS:

1. A lockable motor assembly for use in a well bore comprises: the stator; a rotor rotatably mounted in the stator; a locking member movable axially of the motor between a first position in which the locking member is rotationally fast with the stator and is in engagement with the rotor to prevent rotation of the rotor relative to the stator, and a second position in which one of the stator and the rotor is free to rotate relative to the locking member to permit relative rotation between the stator and the rotor; and holding means for holding the locking member in the first position and selectively releasable to permit the locking member to move to the second position.
2. A lockable motor assembly according to claim 1 wherein, the locking member when in its first position is rotationally fast with the rotor and when in its second position is spaced from the rotor to permit rotation of the rotor relative to the locking member and the stator.
3. A lockable motor assembly according to claim 1 or claim 2 wherein, the locking member has a non-circular profile which, when the locking member is in the first position, engages a complementary non-circular profile provided on the rotor.
4. A lockable motor assembly according to claim 3 wherein, the non-circular profile on the locking member is provided by a projection which, when the locking member is in the first position, engages a complementary recess provided in the rotor.
5. A lockable motor assembly according to any preceding claim wherein, means sensitive to hydraulic pressure within the motor assembly are provided for releasing the holding means when the pressure within the motor assembly reaches a predetermined value.
6. A lockable motor assembly according to claim 5 wherein, the pressure sensitive means comprises a differential area piston provided by the locking member.

7. A lockable motor assembly according to any preceding claim wherein means are provided for maintaining the locking member in the second position after it has been shifted from the first position to the second position.
8. A lockable motor assembly according to any preceding claim wherein, the locking member includes a through passage which provides fluid communication from the proximal end of the motor assembly to the input to the motor.
9. A lockable motor assembly according to claim 8 wherein, the rotor of the motor includes a through passage which, when the locking member is in its first position, communicates with the through passage in the locking member to provide a fluid passage from the proximal end of the motor assembly to the distal end thereof.
10. A lockable motor assembly according to any preceding claim wherein the holding means is one or more shear pins or shear rings.
11. A lockable motor assembly according to any preceding claim wherein the motor is a PDM motor.
12. A lockable motor assembly according to any preceding claim in combination with a hydraulically settable packer and/or anchor wherein the holding means is releasable by hydraulic pressure and wherein the hydraulic pressure required to release the shear means is higher than the hydraulic pressure required to set the packer and/or anchor.
13. The combination of claim 12 including a whipstock and one or more mills connected to the whipstock whereby the combination forms a one-trip assembly which may be run into a well, oriented, the packer and/or anchor set, the motor released, the mill released from the whipstock, and the motor operated to mill a window in casings surrounding the whipstock.

14. A combination according to claim 13 wherein the leading mill is a PDC drill bit capable of drilling formation whereby the combination may drill a lateral in the same trip as milling a window in the casing.



Application No: GB 0018136.2
Claims searched: 1-14

Examiner: Peter Squire
Date of search: 11 December 2000

Patents Act 1977 Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): F1F FEY E1F FEF

Int Cl (Ed.7): E21B 4/02

Other: Online:WPI,EPODOC,JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	US 4705117 (Warren et al) see e.g.col.4 line 12 to col.5 line 48	1, 3-7, 10, 11

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.